

Fundamental Mechanisms of Incongruent Reduction

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(DMR-0341010)*



“Incongruent Reduction (IR)” refers to a fluid/solid chemical reaction that results in the reduction of a solid compound via the formation of a new solid product. IR reactions have recently been used by the PI’s to produce very high-melting, erosion-resistant, and light-weight nozzle liners for solid-fueled rockets (Fig. 1). Such novel reaction processing is an attractive, cost-effective means of manufacturing advanced ceramic composites with complex 3-D shapes for a host of aerospace, automotive, energy production, defense, and chemical/materials processing industries. This project is aimed at obtaining a basic understanding of the mechanisms of IR reactions via study of a model system: IR of Al_2O_3 by a Mg-Al melt, which occurs via formation of MgAl_2O_4 . Such research has led to development of novel *in situ* x-ray diffraction analyses at liquid/solid interfaces using sealed, controlled-atmosphere heating cells (Fig. 2).



Fig. 1. Rocket nozzle liner via IR process (U.S. Patent 6,598,656, Sandhage, et al.)

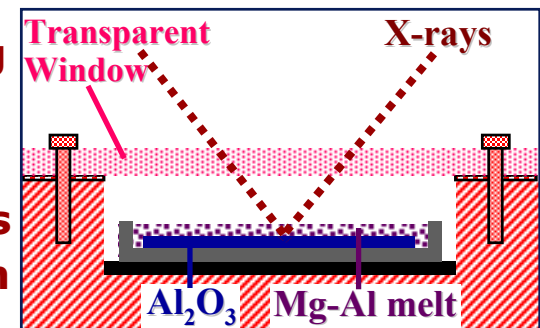


Fig. 2. Novel heating cell for *in-situ* XRD analyses.

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This research has been (Ohio State Univ., OSU) and is being (Georgia Tech., GT) integrated with education via activities such as:

- ◆ **Integration into classroom lectures:**
 - **"Principles of Materials Science and Engineering" (MSE 605, Snyder/OSU)**
 - **"Materials Characterization" (MSE 715, Snyder/OSU)**
 - **"High-Temperature Corrosion" (MSE 736, Sandhage/OSU)**
 - **"Introduction to Engineering" (MSE 1001, Sandhage/GT)**
 - **"Diffraction Studies" (MSE 6105, Snyder/GT)**
 - **"Scattering Theory" (New graduate class, Snyder/GT)**
- ◆ **Integration into undergraduate research projects on IR-based processing (6 undergraduates involved to date):**
 - **"Ceramic body armor" (Sandhage/OSU)**
 - **"Bulk metallic glass composites" (Sandhage/OSU)**
 - **"Rocket nozzle composites" (Sandhage/GT)**